## REMARKS

Applicants respectfully request reconsideration of the present application in view of the below remarks. In addition, Applicants thanks the Examiner for his time and consideration during a telephonic interview on May 2, 2008, with Applicant's representative, Marianne M. Downing. During this interview, the Examiner and Applicant further discussed the relevance of the Gillio reference to the instant claims and application. In addition, during this interview, the Examiner conceded that the Gillio reference relates primarily to a virtual reality surgical simulation system, whereas the present the claims and the instant invention relate to a non-virtual surgical simulation system. No agreement was reached on the claims.

Pending claims 1-23 are rejected, of which claims 1, 12 and 17 are in independent form.

The Prior Art Rejections

The Examiner rejects claims 1, 2, 4-9, 11-14, 16-19 and 22-23 under 35 U.S.C. §103(a) over U.S. Patent No. 5,704,791 to Gillio in view of U.S. Patent Application No. 2003/0031993 in view of Pugh.

Claim 1 requires a surgical training system comprising a first instrument tracking module coupled to the base for tracking a position of a first instrument during a training procedure performed by a user, and a workstation coupled to the first instrument tracking module for processing position information of the first instrument to objectively analyze performance of the user as compared to one or more experts.

As described on page 11, line 4 et seq., of Applicants' specification, a "database is formed by tracking instrument position during a training procedures performed by experts." That is, experts perform a procedure on a workpiece while instrument position is tracked and stored for comparison against the same procedure performed by a trainee to objectively evaluate the trainee's performance, as further described on pages 11-12, for example.

The Examiner has admitted that Gillio fails to teach "*processing position information of the first instrument to objectively analyze performance of the user as compared to one or more experts*". Applicants concur. To provide this teaching of claim 1, the Examiner relies on Pugh. Applicants have read and studied the entire Pugh reference, and Applicants cannot find anything in Pugh that teaches or suggests "*processing position information of the first instrument to objectively analyze performance of the user as compared to one or more experts*". In fact, Pugh does not provide this teaching at all. Pugh instead relates to a system for capturing student performance during a simulated medical exam that is "performed ***manually*** using ***direct manual contact*** with an organ, body surface or an anatomical region such as the abdomen" (Pugh at para. 11, emphasis added) where the **data being processed in Pugh is *data from the anatomical simulator* the user interacts with manually, NOT *data from an instrument* or relating to *position information of an instrument* that a user is using during a training procedure** (Pugh at para. 11). Thus, Pugh relates only to manual exams, performed only with a hand, and Pugh collects and uses only pressure versus time data that is collected at the workpiece, to compare with a "reference exam," performed by an expert, during which the same data was collected.

Pugh never describes use of, processing of, or analysis of any type of position information of any instrument, and certainly does not teach or even suggest tracking instrument position, because Pugh ONLY relates to manual exams; no instruments are ever used or even suggested in Pugh. Furthermore, Push does not even track or considers the position or location of the hand performing the examination! Pugh is concerned only with collecting and analyzing pressure information (e.g., pressure versus time) (see, e.g., Pugh at para. 50) received at/collected at an anatomical simulator, not any type of position information of an instrument. Pugh is analyzing user performance based on pressure information received from a workpiece that a user is contacting manually. This is the opposite of what the present invention describes. The instant invention relates to tracking and processing position information of the entity performing a medical/surgical procedure (i.e., an instrument), whereas Pugh tracks and processes a different type of information (pressure) that is received from the entity (anatomical simulator) on which a medical exam is being conducted.

From the perspective of one of skill in the art, as compared with the instant invention (and even compared with Gillio), therefore, Pugh collects very different data, from the opposite perspective, from a very different type of a procedure, conducted in a very different manner, and conducted without the use of an instrument, tool, or implement of any kind. In addition, as the Examiner has conceded, Gillio is directed to a virtual system, and Gillio's system mostly is implemented via joysticks, mice, and other elements that simulate surgical instruments. Pugh, however, deals with a non-virtual simulation system that simulates no instruments, but instead simulates anatomy being touched with an actual human hand. Thus, Applicants fail to see where there could be any motivation to use, apply, or combine the teachings of Pugh with a virtual reality system like that of Gillio. As the Examiner admits, Gillio does not teach "*processing position information of the first instrument to objectively analyze performance of the user as compared to one or more experts*". Pugh similarly fails to teach or suggest processing of any type of position information of an instrument, because Pugh never even mentions or suggests use of any instrument or collecting any type of position information whatsoever. It is impossible for Pugh's system to teach processing of information that it never even collects!

Additionally, Applicants cannot see how one of skill the art would expect the combination of Gillio and Pugh to be successful. It is readily apparent that even if Gillio and Pugh were combined, the invention as recited in claim 1 could not possibly be achieved. Applicants further maintain that one of skill in the art would not be motivated to combine Gillio with Pugh, because Gillio is relating to using simulated instruments and processing the interaction of these instruments with image data to provide a "virtual reality" simulation of a surgical procedure, whereas Pugh deals with a very different type of medical procedure – a manual exam, not one performed with instruments – and deals with the "other" side of the procedure (the workpiece end), where the data being processed relates pressure information from the training device being touched, not the motion of the actual touching.

Assuming *arguendo* that one of skill in the art had motivation to combine Gillio and Pugh, the invention as recited in claim 1 still would not be achieved. Pugh's teaching would provide processing of pressure versus time information from a workpiece, which would provide

no information or analysis about position information of an instrument as compared to that of an expert. Thus, it is not seen how all of the limitations of claim 1 would be achieved, because the combination of Gillio and Pugh would still fail to teach "processing position information of the first instrument to objectively analyze performance of the user as compared to one or more experts".

For at least the above reasons, Applicants respectfully submit that the virtual surgical training system taught by Gillio, as further modified by Pugh, clearly does not teach claim 1's required limitation of "*processing position information of the first instrument to objectively analyze performance of the user as compared to one or more experts*". Accordingly, Applicant submits that claim 1 is patentably distinguishable over Gillio and Pugh, taken individually or in combination. For at least the same reasons, Applicant submits that claims 2-23 are also distinguishable over Gillio and Pugh, taken individually or in combination.

Applicants further submit that Damadian (US 6544041) and Younker (US 5620326) fail to overcome any of the shortcomings of Gillio and Pugh discussed above in detail. Damadian discloses what he calls a "surgical simulation system" that uses a mannequin with some internal organs and an optical tracking system that includes a probe as one source of location information. Damadian then shows how he can merge the position of a single probe onto the anatomy of the mannequin through the display module. Damadian does mention determining the position and orientation of a probe relative to a mannequin during a surgical simulation, but this data is not processed or analyzed to ascertain user performance. Indeed, Damadian never teaches or suggests that his system provides any teaching or education functionality that involves comparison of user performance to any standard or to others (e.g., experts) who have performed the same operation, or that it could be adapted to be used as such. Instead, Damadian merely uses the probe position data to display to a trainee, during the procedure, the probe position and movement in a composite anatomical image that the trainee is viewing (see Damadian at col. 2, line 1 through col. 3, line 18). Essentially, the system of Damadian is providing merely an electronic pointer registered to an anatomic dataset, with no mention of data collection or processing of position or other information. This is completely unrelated to the teachings of

claim 1. Thus, Applicants maintain that one of skill in the art would not view the system of Damadian as having any overlap with the art area or claims of the instant invention. Accordingly, Applicants argue that (1) one of skill in the art would not be motivated to combine Damadian with any of the references of record; and (2) even if Damadian were combined with one or more of the references of record, none of the claims of the instant application would be achieved.

Younker merely discloses an anatomical simulator that includes a so-called "suture training pack" to enable practice in dissection, clamping, and suturing of arteries and veins (col. 6, lines 25-27). Younker describes nothing about tracking the position of an instrument. Younker has additional deficiencies, discussed further below in connection with claim 10.

For at least the above reasons, Applicants maintain that claim 1 (and all claims dependent therefrom, namely claims 2-11) are patentable over the art of record, taken alone or in combination. In addition, claims 12 and 17 include limitations similar to those of claim 1. Applicants likewise maintain that claims 12 and 17, together with all claims dependent therefrom (i.e., claims 13-16 and 18-23, respectively) are patentable over the art of record, for at least the same reasons discussed above in connection with claim 1.

Although Applicants maintain that all dependent claims are patentable because they depend from patentable parent claims, Applicants also provide additional support below for the patentability of selected dependent claims.

Rejection of dependent claims 5 and 6.

Dependent claim 5 expressly requires a data processing module that computes a score for one or more parameters based on position information of the first instrument during one or more training procedures. Dependent claim 6 (which depends from claim 5) expressly requires at least one parameter processing module selected from an elapsed time module, a path length module, a motion smoothness module, a depth perception module, and a response orientation module. The Examiner alleges that col. 3, lines 5-10 and col. 18, lines 25-40 of Gillio teach (1) a data

processing module that computes a score for one or more parameters based on the position information of the first instrument during one or more training procedures and (2) at least one parameter processing module pertaining to "response orientation", which the Examiner likens to position. After reading the reference and the cited passages carefully, Applicants do not understand the Examiner's basis for this rejection. The cited passages in Gillio merely state:

> The task questions require the user to go through the virtual image data in a particular manner using the scope or other virtual tool device and can determine whether or not the test taker is correctly performing the operation. In the tutorial or teaching mode the present invention provides feedback to the user such as the quality of performance of the user or giving helpful hints to the user to perform the required tasks . . . For example, in a medical embodiment, the virtual device might ask a test taker to go to a particular location in the anatomy and then perform a biopsy. Questions may be inserted in the test before, during or after a particular operation (such as a bronchoscopy). A multitude of tasks may be required of a student during the test procedure. The test taker may chose between different modes, such as an illustration, practice or exam mode. As a result of students tests, reports may be issued relating to the experience a particular student had during the test, how well they did, in comparison to the correct procedures with the individuals performance, and an indication of the performance of all individuals taking these tests for a particular question..

Applicants have considered the cited passages carefully and still can find nothing in this passage whatsoever having to do with either computing "a score for one or more parameters based upon the position information of the first instrument over the course of the one or more training procedures" (as required by claim 5) or "at least one parameter processing module selected from an elapsed time module, a path length module, a motion smoothness module, a depth perception module, and a response orientation module," (as required by claim 6). Further, Applicants can find nothing relating to the Examiner's assertion that Gillio teaches processing "response orientation". At best, Gillio states that "questions" might be asked of a user. This is absolutely not the same as collecting or processing position information!

Furthermore, although Gillio indicates that an individual might receive a report as to how well the student performed in comparison with a correct procedure, Gillio never describes what specifically forms the basis of the comparison. Gillio never says the report is based any type of position information whatsoever. The comparison could, for example, be based solely on the user's answers to the questions that Gillio poses. It could be based on whether or not the student

biopsied the "correct" organ. Whatever Gillio's comparison is based on (and Gillio does not provide specifics), Gillio clearly never mentions or considers position information of an instrument. A mere sentence stating that Gillio provides feedback as to the user's quality of performance and whether the user is correctly performing the operation simply cannot be interpreted to teach computing a score based on position information (claim 5) or processing of any the very specific position related parameters (i.e., elapsed time, path length, motion smoothness, depth perception, and/or response orientation) recited in claim 6. Thus, it is not seen how Gillio can be viewed as teaching the limitations of either claim 5 or claim 6.

The other references do not compensate for Gillio's lack of teaching as to the subject matter of dependent claims 5 and 6. Accordingly, for at least the above reasons, Applicants maintain that claims 5 and 6 are patentable over the art of record, taken alone or in combination. Thus, Applicants respectfully request that the rejection of claims 5 and 6 over the Gillio reference be withdrawn.

Rejection of Dependent claim 10

The Examiner admits that the combination of Gillio and Pugh fails to teach claim 10's limitation of a system where the training object includes simulated skin. The Examiner has asserted that col. 7, lines 15-25 of Youker allegedly teaches the "simulated skin" of claim 10. The passage cited by the Examiner, together with some relevant text around it, reads:

> A suitable elastomeric formula for making such a dry suture training procedure pack is a two part expandable urethane foam. One suitable urethane foam is available from BJB Company, Garden Grove, Calif., part number TC 281. It is preferable to mix in agents that affect the foaming and skin formation of the urethane to provide a contoured foam layer that has a thin outer skin and large air cells, providing a low density, highly flexible foam. Preferably quantities of water and an oil or grease, such as petroleum jelly, are added to the formulation to yield a reduced exterior skin thickness and increased air cell size .

Although the cited passage includes the words "skin" and "cells", these terms have nothing whatsoever to do with anatomy. Rather, as those of skill in the art will recognize, these are terms of art in the manufacture of urethane foam, and, thus, Youker is instead referring to the "cells" and "skin" that naturally forms in and/or on some types of urethane foam. To assist in

the Examiner's understanding, the website of the Polyurethane Foam Association (PFA), in its glossary at http://www.pfa.org/glossary.html , provides these helpful definitions of various types of "skin" and "cells" as they relates to their formation on urethane foam (a copy of this glossary is provided as Exhibit A to this Response):

> **Basal Cells** Larger, irregular cells found just under the surface skin of a molded foam part.
> **Cell** The cavity remaining in the structure of flexible polyurethane foam surrounded by polymer membranes or the polymer skeleton after blowing is complete.
> **Cell Count** The number of cells per linear inch or centimeter, expressed as pores per inch or pores per centimeter.
> **Cell Opening** In foamed materials, the breaking of membranes within the cell structure, permitting flow of air through the material.
> **Cell Size** The average diameter of the cells in the final flexible polyurethane foam product, often measured in micron units.
> **Core** The internal portion of foam, free of any skin
> **Elephant Skin** Surface creasing effect due to lateral resistance of a stiff, thick flexible polyurethane foam when compressed parallel to its face.
> **Integral Skin Foam** A molded foam having a dense, tough outer skin and a relatively lower density core. The product is achieved in a single pour using a combination of chemical and mechanical aids.
> **Skin** The higher-density outer surface of a foam usually occurring when the foam surface cools more rapidly than the core

The usage explained in the above glossary is entirely consistent with Youker's teachings. For example, As Youker states at col. 4, lines 59-64:

> The torso is formed from a flexible elastomeric material. Suitable materials include two-part urethane foams that are self-skinning upon cure and silicone. Other suitable materials include silicon rubber and urethanes.

Thus, Youker never teaches or suggest that the "skin" formed on the urethane foam is intended to correspond to, simulate, or be used as any human or animal skin. Rather, Youker's skin is an actual "skin" formed on urethane foam, as that term is understood by those in the plastics arts. Indeed, Youker's system never even addresses anything whatsoever to simulate skin, as that term is understood in the anatomical sense.

In view of the above, Applicants maintain that claim 10 is patentably distinct over the art of record, taken alone or in combination. Accordingly, Applicants respectfully request that the rejection of claim 10 over the art of record be withdrawn.

Based at least on the above arguments, Applicants submits that claims 1-23 are allowable over the art of record, taken individually or in combination. Accordingly, Applicants respectfully request that the rejections of claims 1-23 be withdrawn. Applicant respectfully requests a notice of allowance for these claims.

The Examiner is respectfully invited to telephone the undersigning attorney if there are any questions regarding this Response or this application.

Applicant does not acquiesce to any assertion made by the Examiner not specifically addressed herein.

The Assistant Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or credit any overpayment to Deposit Account No. 500845, including but not limited to, any charges for extensions of time under 37 C.F.R. §1.136.

Respectfully submitted,

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# Exhibit A

# (Appl. No. 10/797,874)

# FLEXIBLE POLYURETHANE FOAM GLOSSARY

**Acoustical Flexible Polyurethane Foam** Foam designed to be attenuated (dampen sounds), or be nonattenuted (transmit sound as in loud speakers).

**Additive** A material used to modify the properties, processing, or end use of a base polymer. The amount of additive used is usually expressed in parts per hundred (by weight) of the total resin in the polymer formulation.

**Air Flow** Amount of air expressed in cubic feet per minute, that can be drawn through a 2"x 2"x 1" foam sample at .5-inch water pressure differential. Air Flow is measured by a test (ASTM D3574).

**Air Traps** Voids in molded foam parts caused by encapsulation of air pockets during mold fill-out. These voids have smooth, shiny surfaces.

**Amine** A class of compounds used as catalysts in polyurethane foam reactions. Amines are characterized by having N, NH or NH2 groups in the molecule.

**Antioxidants** Materials which when added to a flexible polyurethane foam formulation improve the resistance of the foam to oxidative type reactions, such as scorch resulting from high exothermic temperatures.

**Anti-Static Flexible Polyurethane Foam** Foam that contains electrically conductive materials to prevent static electricity buildup or promote static discharge. It is used primarily in packaging applications, such as for electronic components.

**ASTM American Society For Testing and Materials** An organization devoted to the establishment of standard methods and procedures for testing materials in the United States.

**Auxiliary Blowing Agent (ABA)** An additive used in the production of foam which supplements the primary blowing agent (water), and can be used to make foam softer or lighter. Compounds used to produce gases to expand, or blow, flexible polyurethane foam during production. Auxiliary blowing agents are low temperature boiling solvents, such as methylene chloride, acetone, hydrochlorofluorocarbons, and isopentane.

**Ball Rebound** A test procedure (ASTM D3574) used to measure the surface resilience of flexible polyurethane foam. The test involves dropping a steel ball of known mass from a predetermined height onto a foam sample. The rebound height attained by the steel ball, expressed as a percentage of the original drop height, is the ball rebound resilience value.

**Basal Cells** Larger, irregular cells found just under the surface skin of a molded foam part.

**Blowing** The process by which flexible polyurethane is foamed during production. In all cases, blowing occurs when water and TDI react to form CO2. [Also see Auxiliary Blowing Agent (ABA).]

**Board Foot** A unit of foam measurement equal to a square foot of material one inch in thickness.

**Board Stock** Flat sheets of flexible foam cut from large blocks or buns of foam.

**Boardy** Flexible polyurethane foam with a stiff or rigid feel, generally indicated by high 25% IFD values and low compression modulus.

**Bonded Foam** Flexible polyurethane foam particles or shredded flexible polyurethane foam (often manufacturing scrap) that has been glued to form a useful product. The resultant foam block is "peeled" into the desired thickness. Largest use is for carpet cushion. [Also see Rebonded Foam.]

**Bonding** The combination of two or more components into a composite. Foam is often adhered to other foam grades or to polyester fiber.

**Boston Chair Test** Boston Fire Department test method to measure performance of flexible polyurethane foam padding materials when exposed to a fairly severe flaming ignition source. This test is a full scale composite test. Test method is now similar to California TB 133.

**Bottom Out** Lack of support under full weight load. This characteristic is often found in low-density foam. This term is very subjective, as a foam may bottom out with a heavy person, and be very comfortable to a lighter-weight individual. The problem can be reduced by specifying foam with higher density and/or greater compression modulus value.

**Buffed** Flexible polyurethane foam pieces that have been shaped or contoured by removal of foam using abrasives.

**Bun** A segment of foam cut off from continuously produced slabstock type of foam.

**California 117 Foam** Flexible polyurethane foam that will meet the component combustibility requirements of the California Bureau of Home Furnishings' Technical Bulletin No. 117 (TB117).

**California Technical Bulletin 133 (TB 133)** A composite test to determine the combustion performance of a complete furniture construction "system". This is designed to be an evaluation of furniture performance when exposed to a large ignition source. The composite test evaluates total furniture construction rather than foam, fabrics, fiber or other construction components on an individual basis.

**Catalyst** A chemical that changes the rate of reaction of a chemical process, but is not consumed or produced during the reaction. (Catalysts are required for foam production to balance rates of competing reactions and to attain desired physical properties.)

**Cell** The cavity remaining in the structure of flexible polyurethane foam surrounded by polymer membranes or the polymer skeleton after blowing is complete.

**Cell Count** The number of cells per linear inch or centimeter, expressed as pores per inch or pores per centimeter.

**Cell Opening** In foamed materials, the breaking of membranes within the cell structure, permitting flow of air through the material.

**Cell Size** The average diameter of the cells in the final flexible polyurethane foam product, often measured in micron units.

**CFC-Free Foam** Flexible polyurethane foams that have been made without the use of chlorofluorocarbons as auxiliary blowing agents.

**Compression Force Deflection (CFD)** A measure of the load bearing ability of a foam. It is the force exerted against a flat compression foot larger than the specimen to be tested. The value can be expressed at 25%, 40%, 50%, and/or 65% compression (ASTM D3574). Note: previously called "CLD (Compression Load Deflection)".

**Clickability** The ability of a flexible polyurethane foam to recover from the pinching effects of die-cutting.

**Closed Cells** Foam cells having intact cell membranes thereby reducing or eliminating passageways for airflow.

**Closed Pour** The case in molded foam production in which the mold lid is closed and locked and the foaming mixture is introduced through one or more special ports in the lid of the mold.

**Coarse Cells** Large cells averaging 20 to 30 cells per lineal inch or fewer.

**Cold Molding** Molding process for the production of high-resiliency foam in which the foam is cured at or near room (ambient) temperature. Pouring is carried out without adding heat.

**Colorant** Dyes or pigments added to impart color to the final foam.

**Combustion Modified Foam** Flexible polyurethane foams manufactured by using additives based on chlorine, bromine, and phosphorus chemistry to reduce ease of ignition. Hydrated alumina or melamine is also used.

**Combustion Modifying Additive** A material that, when added to flexible polyurethane foam, will cause the foam to be more difficult to ignite or burn less rapidly or lose less weight during a fire than without that material. [Also known as "Fire Retardants".]

**Comfort** The ability of the cushioning structure to deflect at the surface and to conform to body shape, preventing a concentration of pressure on the body without bottoming out.

**Compression Modulus** Ratio of a foam's ability to support force at different indentation (or compression) levels. It is determined by taking the ratio of the foam's IFD at 25% indentation and 65% indentation (65% IFD/25%). The compression modulus is typically a function of foam chemical formulation and the manufacturing process. In most cases, the higher the density the greater the compression modulus. Other terms that are used interchangeably are: support factor, and modulus. The PFA recommends that compression modulus or support factor be used when referring to foam support properties.

**Compression Set** A permanent partial loss of initial height of a flexible polyurethane foam sample after compression due to a bending or collapse of the cell framework within the foam sample. A high value of compression set will cause a flexible polyurethane foam cushion to quickly lose its original appearance with use, leaving its surface depressed or "hollowed out". Compression set is measured in the lab by compressing a foam sample 90% of its thickness (or down to 10% of its original thickness) and holding it at 70

degrees C (or 158 degrees F) for 22 hours. Compression set is most commonly expressed as a percentage of original compression. Other deflections, times, and temperatures can be used.

**Conventional Flexible Polyurethane Foam** Polyether type polyurethane foams made by the basic manufacturing process without polyol modifiers or other additives.

**Convoluted** A foam fabrication process involving the use of a special cutting equipment to produce a foam sheet with dimples. The base under the dimples can be varied in thickness. Peaks can be produced from 1/2" to over 4" in height. Foam dimples can be produced in a number of shapes including egg-like designs, waves, squares or sharply-defined points.

**Core** The internal portion of foam, free of any skin.

**Core Density** The density of the foam sampled without skin, glue lines or compressed sections at or near the center of the final foamed shape.

**Crushing** Usually a mechanical or vacuum-assisted procedure to open the closed cells of a high resilience slabstock or molded foam.

**Cure** A term referring to the process whereby chemical reactions approach completion. At 100% completion, a foam should have 100% of the physical properties attainable with that particular formulation.

**Cure Time** The length of time required for sufficient reaction completion to develop a desired level of polymer strength and dimensional stability and to attain ultimate physical properties.

**Dead Foam** Foam that has a low resiliency and only slowly regains its original shape after deformation.

**Deflect** To compress, usually by a specified amount or percentage.

**Demold Time** The time between the discharge of the foam ingredients from the mixing head and the time at which a molded object may be removed readily from the mold without tearing or altering its shape and without post-expansion.

**Densified** A material that has been made more dense by permanently compressing a unit mass into a smaller volume.

**Density** A measurement of the mass per unit volume. It is measured and expressed in pounds per cubic foot (pcf) or kilograms per cubic meter (kg/m3) (Test Method ASTM D3574).

**Die Cutting** The "stamping out" of foam into parts, useful for long runs of cut parts requiring consistency in size.

**Discoloration** The gradual yellowing of foam due to a photochemical reaction. It is faster in sunlight than in artificial light, although it occurs in both. Fresh foam may discolor in the center of the block as a result of thermal or chemical events. (Does not affect physical properties.)

**Dish** Description of what occurs when a weight is placed on the center of a cushion or

mattress and the corners rise up in response.

**Durability** As applied to flexible foams, the term refers to how well a foam retains its load bearing capacity and shape with use. Most measures of durability are done with laboratory-scale tests.

**Dynamic Fatigue** A durability test performed in the laboratory using roller-shear or pounding type mechanisms. A roller, longer than the foam width, is rolled back and forth across the foam. The roller is mounted in an offset position to impart a shearing action. (ASTM D3574).

**Elastomer** Polymers which resist and recover from deformation produced by force, similar in behavior to natural rubber.

**Elephant Skin** Surface creasing effect due to lateral resistance of a stiff, thick flexible polyurethane foam when compressed parallel to its face.

**Elongation** The percent that a specially shaped sample will stretch from its original length before breaking. (Test Method ASTM D3574).

**Exotherm** The heat released as a by product of some chemical reactions. All flexible polyurethane foam production reactions are exothermic.

**Fatigue (Flex Fatigue)** A softening or loss of firmness. Fatigue can be measured in the laboratory by repeatedly compressing a foam sample and measuring the change in IFD.

**Filled Foam** The addition of inorganic materials such as marble dust, barium sulfate, silica or clay, in foam to increase the density. Fillers are often added to increase the Support Factor. Filled polyurethane foam may be inappropriate for some applications, if the polymer content of the filled foam is not sufficient for the intended application before fillers are added. The fillers are not chemically bonded into the foam polymer. They are instead mechanically trapped within the molecular structure of the polymer. Filled foams with low polymer content or a high percentage of filler material tend to have less strength and durability.

**Fine Cells** A term used to describe foam with a cell count of 80 or more per lineal inch.

**Fingernail Test** A subjective test to determine the recovery of flexible foam when it is indented with a fingernail or sharp object.

**Fire Retardants** A material that, when added to flexible polyurethane foam, will cause the foam to be more difficult to ignite or burn less rapidly or lose less weight during a fire than without that material. [Also known as "Combustion Modifying Additives".]

**Flame Lamination** The practice of bonding flexible foam to a fabric or other material (film, etc.) by melting one surface of the foam with a flame source and quickly pressing it to the other substrate before the melted material resolidifies. [Also called Flame Bonding.]

**Flex Fatigue** The loss of foam firmness after flexing the foam a predetermined number of cycles.

**Foam** A lightweight cellular material resulting from the introduction of gas bubbles into a reacting polymer.

**Formulation** The list of chemicals and their relative amounts to be used in the preparation of a foam.

**Friable** A term used to indicate the crumbling, flaking, or powdering of a foam when the surface is rubbed.

**Frothing** A foaming technique in which air or other gases that are mechanically whipped into the polyurethane mixture using a high-shear mixer prior to the foam reaction.

**Gel Time** The time between the discharge of the foam ingredients from the mixing head and the point at which the foam has developed enough gel strength to resist light impressions and is dimensionally stable.

**Graft or Polymer Polyol** Polymers with active hydroxyl groups that have other organic groups or polymers "grafted" to the polyol molecule. These grafted organic compounds serve to reinforce the strength or modify other properties of the flexible polyurethane foam product.

**Hand** Is the feel of the foam as the hand is rubbed lightly over the surface. For most furniture, bedding and textile applications, foam having a stiff or hard feel to the touch is described as having poor hand. In home furnishings, foam with a good hand has a springy, velvet feel, while abrasive pads, firm filler, and some packaging require a hand that is quite the opposite.

**High Resilience (HR) Foam** A variety of polyurethane foam produced using a blend of polymer or graft polyols. High resilience foam has a less uniform (more random) cell structure different from conventional products. The different cell structure helps add support, comfort, and resilience or bounce. High resilience foams have a high support factor and greater surface resilience than conventional foams and are defined in ASTM D3770.

**Hot Molding** A flexible molded foam production process in which high oven temperatures are used to drive the curing reaction in foams made from relatively low-reactivity polyols.

**Hot Wire Cutting** A high-temperature wire used to cut foam. This fabrication process is used typically for intricate parts. A ventilation hood should be used with this technique to exhaust fumes. Note: This procedure is not suitable for all foams.

**Humid Aging** An accelerated aging test method under conditions of high humidity and temperature. (ASTM D3547)

**Hydrophilic** An affinity for water.

**Hydrophobic** A repellency for water.

**Hysteresis** The ability of foam to maintain original support characteristics after flexing. Hysteresis is the percent of 25% IFD loss measured as a compression tester returns to the normal (25% IFD) position after measuring 65% compression. Lower hysteresis values, or less IFD loss are desirable. Current research indicates that hysteresis values may provide a good indication of overall flexible foam durability. Low hysteresis in conventional foam is equal to less IFD loss.

**Indentation Force Deflection (IFD)** A measure of the load bearing capacity of flexible

polyurethane foam. IFD is generally measured as the force (in pounds) required to compress a 50 square inch circular indentor foot into a 4 inch thick sample, typically 15 inches square or larger, to a stated percentage of the sample's initial height. Common IFD values are generated at 25 and 65 percent of initial height. (Reference Test Method ASTM D3574 ). Note: Previously called "ILD (Indentation Load Deflection)".

**Integral Skin Foam** A molded foam having a dense, tough outer skin and a relatively lower density core. The product is achieved in a single pour using a combination of chemical and mechanical aids.

**Isocyanate** A shorthand name for the family of diisocyanates which are one of the two major ingredients in the chemical process by which polyurethane foam is made.

**Laminating** The bonding of layers of foam and/or other materials together into a single composite. This may be accomplished through adhesives or through heat processes like flame lamination.

**Latex** A natural rubber product which is not related to polyurethane foam.

**Loop Slitter** A mechanical slitter which allows continuous slitting of long buns of foam.

**Mixing Head** The device that mixes two or more component streams before dispensing the foam-producing mixture to the foam production surface or mold.

**Mold Packing** The practice of purposely adding more material to the mold than is actually required to just fill it. The extra material serves to accommodate slight changes in material temperatures, mold temperatures, and pour patterns. It is also a way to improve load-bearing properties without changing the foam formulation.

**Molded Foam** A cellular foam product having the shape of the mold cavity in which it was produced.

**Open Cell Structure** A permeable structure in flexible foam in which there is no barrier between cells, and gases or liquids can pass through the foam. Most cell walls have been ruptured to varying extent.

**Peeling** The process whereby thin sheets of foam are cut from a cylinder of foam. Similar to plywood peeling.

**Pieced** Flexible polyurethane foam that has been glued together from two or more smaller pieces. Commonly seen in cushioning to create special shapes or properties, or to use up small pieces produced during fabrication.

**Pockets** The undesirable formation of large cavities or pockets in the foam structure. Pocketing is usually caused by rapid formation and/or release of the blowing agent before the polymer structure has gained sufficient strength to contain the gas. [Also see "Splits".]

**Polyester** A polymeric polyol containing ester groups in the main molecular chain or in side chains.

**Polyether** A polymeric polyol containing ether linkages (carbon-oxygen-carbon links) in the main molecular chain or in side chains.

**Polymer** An organic substance composed of repeating chemical units built up into large

molecules.

**Polymer Density** The density of the material made up strictly by the foam chemistry without fillers or reinforcements included.

**Polyol** A key chemical in foam formulation which, when mixed with diiso-cyanates and other specific ingredients, produces the reaction that causes flexible polyurethane foam to form.

**Polyurethane** Generally, a polymer connected by urethane groups. Urethane linkage and its supplements result from the reaction of polyol with isocyanate.

**Pore Size** The number of cells per linear inch.

**Preflex** The practice of compressing a flexible polyurethane foam sample up to six times to a predetermined thickness before determining IFD. (Reference ASTM D3574). Also used for other properties (e.g. resilience for HR foams).

**Prepolymer** A reacted, but not completely polymerized product. In the polyurethane industry, this is usually a prereacted product formed by reacting polyol(s) or water with diisocyanate(s). The materials normally contain residual free isocyanate groups for further reaction with more polyol(s) or water to produce the final polymer.

**Pressure Release Collapse** Shallow surface voids and/or shear collapse on molded foam parts caused by the sudden release of internal mold pressure or failure of the mold to seal. Usually seen with shiny surfaces and a thin surface skin similar to cold collapse.

**Primary Backing (carpet)** The material through which the carpet fibers are tufted.

**Prime Carpet Cushion** Polyurethane carpet cushion which is made from slabstock polyurethane foam.

**Protocol For Residential Walk-On Test** A standardized testing procedure that can be used by carpet manufacturers, cushion producers, distributors and retailers to evaluate installed residential carpet system performance.

**Rebonded Foam** That foam resulting from a process of adhering small particles of foam back together again to make a usable cushioning product. Various adhesives and bonding processes are used. A typical application for rebonded foam is as carpet underlay. [Also see Bonded Foam.]

**Recovery** The return to original dimension and properties of a flexible polyurethane foam sample after a deforming force is removed. Reinforced Foam [See "Filled Foam".]

**Resilience** An indicator of the surface elasticity or "springiness" of foam. It is measured by dropping a steel ball onto the foam cushion and measuring how high the ball rebounds.

**Reticulated Foam** Flexible polyurethane foams characterized by a three-dimensional skeletal structure with few or no membranes between strands. Reticulated foams are generally used as filters, acoustical panels, and for controlled liquid delivery.

**Roll Goods** Flexible polyurethane foam that has been peeled from a foam "log" or slit from a bun and rolled onto a core for handling purposes. Rolled foam sheets are commonly used for large area padding, such as carpet padding and as quilting foam in

mattresses.

**Scorch** A yellow or brown discoloration of the foam, particularly in the core. Scorching is caused by excessive heat during the exothermic reaction. It occurs mainly in high-water flexible slabstock formulations.

**Seam** The splice line formed by two or more separate pieces of flexible polyurethane foam that have been bonded together.

**Shiners** Light reflected from intact cell walls, noticeable on the cut surfaces of flexible polyurethane foam. A large number of shiners, or shiny spots, indicates a foam with many closed cells.

**Shredded Foam** Flexible polyurethane foam that has been mechanically torn into small pieces or crumbs, for the purpose of creating a loose filling material.

**Skin** The higher-density outer surface of a foam usually occurring when the foam surface cools more rapidly than the core.

**Slab** A section of foam cut from the interior of a large bun.

**Slab Stock** Flexible polyurethane foam made by the continuous pouring of mixed liquids onto a conveyor, creating a continuous loaf of foam.

**Slabstock Production Process** One of the two basic procedures used to manufacture foam. A continuous process in which the reacting foam chemical mix is dispensed on to a moving conveyor belt where the foaming process is completed. This foam is subsequently fabricated into useful shapes.

**Slitting** The process where sheets of foam are cut from a rectangular foam block.

**Static Fatigue** The loss in load bearing properties of a flexible polyurethane foam sample under constant compression of 75% for 17 hours at room temperature. (See "Test Method ASTM D3574"). Struts The structural members of a foam material. These roughly triangular features contain most of the solid polymer and form the cell shape.

**"Supersoft" Foam** Foams that have an IFD measurement within the 4 to 10 pound range having a comparable feel to fiber.

**Support Factor** (see Compression Modulus) Support Factor = 65%IFDÖ25%IFD determined after one minute of rest or recovery. When the support factor is known it can be used in conjunction with a known 25% IFD value to determine the 65% IFD value. Seating foams with low support factor are more likely to bottom out under load.

**Surface Firmness** The number of pounds of force necessary to indent a foam sample by 25% of its original height.

**Surfactants** A term to describe substances that provide resiliency and stability to thin films and that markedly lower the surface tension of liquids, thus permitting easier bubble formation. An integral part of the foam manufacturing chemistry.

**TDI** An abbreviation for toluene diioscyanate.

**Tear Strength** A measure of the force required to continue a tear in a foam after a split or

break has been started and expressed in pounds per inch (lbs/in.). This property is important in determining suitability of foam in applications where the material is sewed, stapled, or otherwise anchored to a solid substrate. Also important in demoldability. (ASTM D3574).

**Tensile Strength** The pounds per square inch of force required to stretch a material to the breaking point. (Reference ASTM D3574).

**Tight Foam** Flexible polyurethane foam with many closed cells, resulting in low air flow measurements.

**Total Vertical Motion (TVM)** The deflection of a seating system during sitting.

**Urethane** Actually a misnomer as applied to polyurethane foam. A colorless, crystalline substance used primarily in medicines, pesticides, and fungicides. Urethane is not used in the production of urethane polymers or foams. The urethanes of the plastics industry are so named because the repeating units of their structures resemble the chemical urethane.

**Virgin Foam** Unfilled flexible slabstock foam that has not been processed in any manner other than cutting to shape.

**Voids** The undesirable formation of large cavities or pockets in a foam structure. Voids are usually caused by poor moldability or incorrect mold filling. In the case of foam buns, voids occur when then blowing and polymerization reactions are out of balance.

**Water Blown** Foam Flexible polyurethane foam in which the gas for expansion is carbon dioxide generated by the reaction between water and an isocyanate material. All flexible polyurethane foam is water blown, although auxiliary blowing agents are often used to obtain special physical properties.

**Windows** The thin membranes formed between cell struts.Windows may be present (a closed-cell foam) or absent (an open-cell foam) depending on the particular foam chemistry used.